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Fecal-coliform bacteria concentrations in streams of the Chattahoochee River National Recreation Area, Metropolitan Atlanta, Georgia, May–October 1994 and 1995

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Significant Findings

- Fecal-coliform bacteria concentrations in the Chattahoochee River were low downstream from Buford Dam, especially nearest the dam, because of dilution from water released from near the bottom of Lake Sidney Lanier.
- Median fecal-coliform bacteria concentrations in the Chattahoochee River increased steadily from less than 20 Most Probable Number of colonies per 100 milliliters (MPN col/100 mL) in the tailwaters of Buford Dam on Lake Sidney Lanier to 790 MPN col/100 mL downstream of Metropolitan Atlanta. During the 1994 and 1995 summer recreation seasons, from 1 to 89 percent of samples collected at 14 Chattahoochee River monitoring sites exceeded the U.S. Environmental Protection Agency (USEPA) review criterion of 400 col/100 mL.
- Georgia Environmental Protection Division standards and the USEPA review criterion for fecal coliform bacteria were commonly exceeded during wet-weather conditions in most Metropolitan Atlanta tributary streams and during most streamflow conditions in several tributaries that drain areas dominated by urban and suburban land uses. During the 1994 and 1995 summer recreational season, from 42 to 100 percent of samples collected at 22 tributary stream-monitoring sites exceeded the USEPA review criterion of 400 col/100 mL.
- Statistically significant positive correlations were found between high fecal-coliform bacteria concentrations and increased discharges and high turbidities in less-developed tributary watersheds dominated by nonpoint sources such as runoff from parking lots, lawns, and pastures.
- In some highly urbanized tributary watersheds, there was an inverse correlation between high fecal-coliform bacteria concentrations and increased discharges and high turbidities, which indicates possible contamination from point sources such as leaking or overflowing sewer lines or discharge from combined sewer overflows.

The Chattahoochee River National Recreation Area (CRNRA) attracts approximately 3.5 million visitors each year with nearly 30 percent of the visitors participating in water-based activities such as fishing and boating. The CRNRA contains about three-fourths of all public green space in a 10-county area of Metropolitan Atlanta (Kunkle and Vana-Miller, 2000).

Introduction

The Metropolitan Atlanta area has been undergoing a period of rapid growth and development. The population in the 10-county metropolitan area almost doubled from about 1.6 million people in 1970 to 3.1 million people in 1995 (Atlanta Regional Commission, written commun., 1999). Residential, commercial, and other urban land uses more than tripled during the same period (Frick and others, 1998). The Chattahoochee River is the most utilized water resource in Georgia. The rapid growth of Metropolitan Atlanta and its location downstream of the headwaters of the drainage basin make the Chattahoochee River a vital resource for drinking-water supplies, recreational opportunities, and wastewater assimilation. In 1978, the U.S. Congress declared the natural, scenic, recreation, and other values

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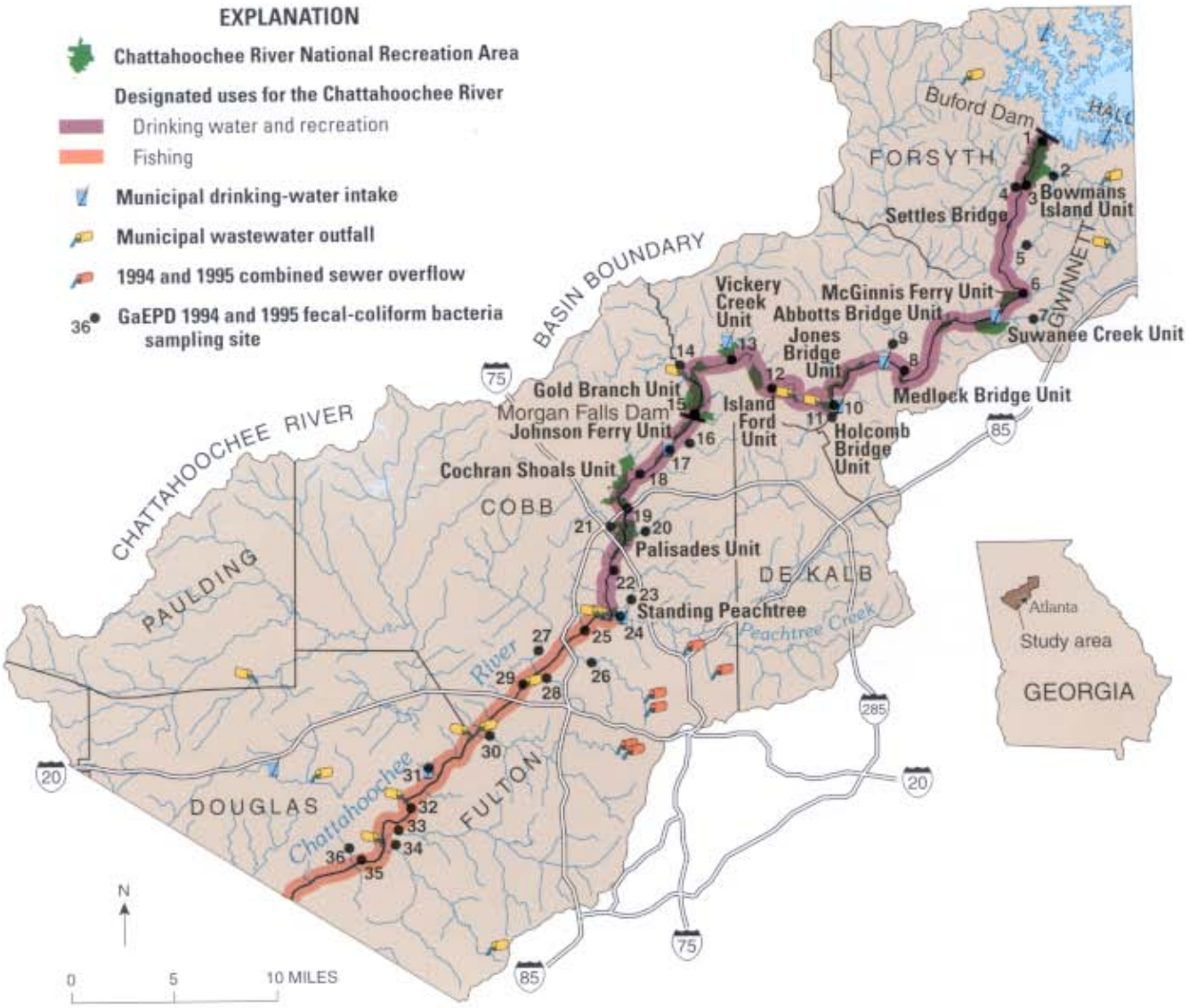


Georgia Environmental Protection Division (GaEPD) 1994 and 1995 fecal-coliform bacteria sampling sites within the study area

Site number	Site name
1	Chattahoochee River—Buford Dam tailwater near Buford
2	Richland Creek
3	Chattahoochee River—State Road 20 near Suwanee
4	James Creek
5	Level Creek
6	Chattahoochee River—McGinnis Ferry Road at Suwanee
7	Suwanee Creek
8	Chattahoochee River—Medlock Bridge Road near Norcross
9	Johns Creek
10	Chattahoochee River—Holcomb Bridge Road near Norcross
11	Crooked Creek
12	Chattahoochee River—Eves Road above Roswell
13	Big Creek
14	Willeo Creek
15	Chattahoochee River—Morgan Falls Dam Forebay at Sandy Springs
16	Marsh Creek
17	Chattahoochee River—Johnson Ferry Road near Atlanta
18	Sope Creek
19	Chattahoochee River—Powers Ferry Road & I-285 near Atlanta
20	Long Island Creek
21	Rottenwood Creek
22	Chattahoochee River—Paces Ferry Road at Atlanta
23	Nancy Creek
24	Peachtree Creek
25	Chattahoochee River—South Cobb Drive near Atlanta
26	Proctor Creek
27	Nickajack Creek
28	Sandy Creek
29	Chattahoochee River—Martin Luther King Jr. Blvd. near Mabelton
30	Utoy Creek
31	Sweetwater Creek
32	Chattahoochee River—State Road 166 near Ben Hill
33	Camp Creek
34	Deep Creek
35	Chattahoochee River—State Road 92 near Fairburn
36	Anneewakee Creek

Figure 1. Location of the Chattahoochee River National Recreation Area and Georgia Environmental Protection Division fecal-coliform bacteria sampling sites in the study area, May–October 1994 and 1995.

of 48 miles of the Chattahoochee River from Buford Dam to Peachtree Creek to be of special national significance. To preserve this reach of the Chattahoochee River, the U.S. Congress created the Chattahoochee River National Recreational Area (CRNRA), which includes the Chattahoochee River downstream from Buford Dam to the mouth of Peachtree Creek and a series of park areas adjacent to the river in northern Metropolitan Atlanta (fig. 1).

Even with this protection, waters of the Chattahoochee River and many of its tributaries in Metropolitan Atlanta did not meet water-quality standards set for designated uses during 1994 and 1995 (fig. 1 and table 1). Much of the degradation of water quality has been associated with areas undergoing rapid urban growth and sprawling suburban development. The resulting conversion of mostly forested land to urban land has multiple adverse effects on water quality. Degradation of water quality may be caused by a number of factors including an increase in nutrient concentrations, sediment and sediment-bound contaminant concentrations (*e.g.*, metals and pesticides) (Frick and others, 1998), and fecal-coliform bacteria concentrations (Center for Watershed Protection, 1999). The presence of fecal-coliform bacteria in streams and rivers indicates that contamination by fecal material from human or animal sources has occurred and contact with these waters can result in exposure to pathogenic bacteria often associated with fecal contamination.

During 1994 and 1995, elevated concentrations of fecal-coliform bacteria were the most common reason that the Chattahoochee River and tributaries did not meet their designated uses of drinking-water supply, recreation, and fishing. According to the Georgia Department of Natural Resources (1997), during 1994 and 1995, 67 of 77 stream reaches assessed in Metropolitan Atlanta did not meet or only partially met water-quality requirements for designated uses. Excessive concentrations of fecal-coliform bacteria were a contributing factor in 63 of the 67 streams that did not meet or only partially met designated uses. High concentrations of fecal-coliform bacteria have the potential to reduce the recreational value of the river and pose a continued threat, with unknown health risks, to humans that come in contact with the water while fishing, boating, rafting, wading, and swimming.

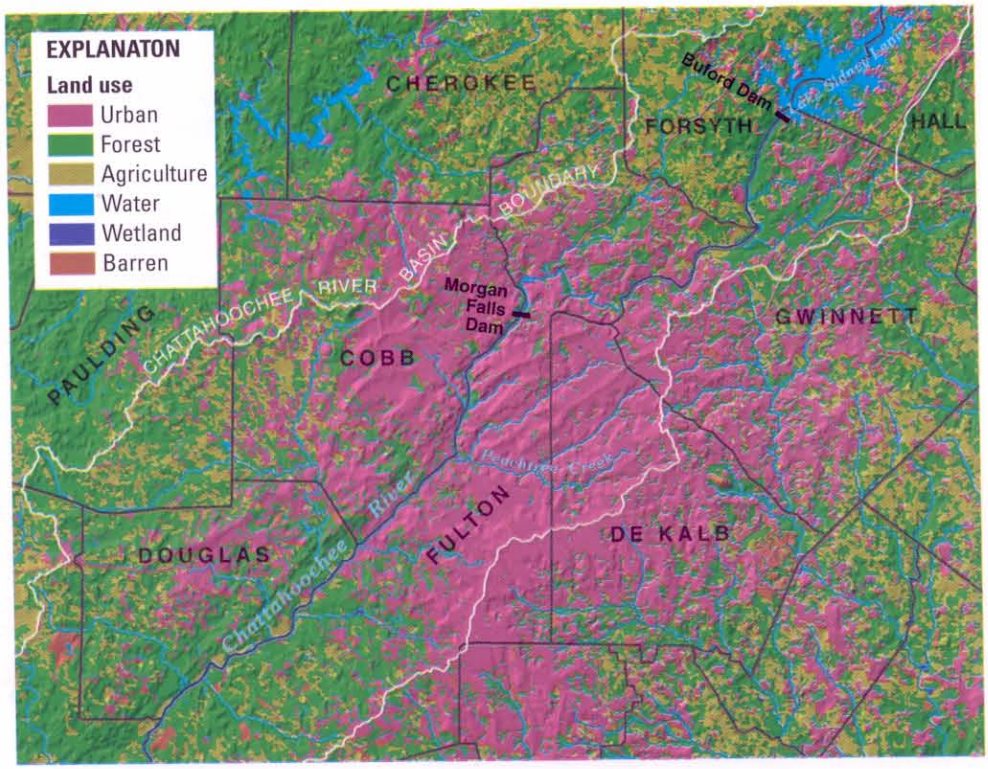


Figure 2. Land use, Metropolitan Atlanta area, 1995 (data from U.S. Geological Survey, 1977–80; U.S. Bureau of the Census, 1991; Atlanta Regional Commission, digital data, 1995; http://www.census.gov/population/www/estimates/countypop.html, 1996).

Project Description

In 1999, the U.S. Geological Survey (USGS) and the National Park Service (NPS) initiated a 2-year project designed to better define microbial contamination in and near the CRNRA, in Metropolitan Atlanta, Ga. As part of the USGS and NPS microbial project, a retrospective analysis of a spatially extensive water-quality data set for the upper Chattahoochee River was analyzed. These data were collected by the Georgia Environmental Protection Division (GaEPD) from May to October in 1994 and 1995 as part of their Chattahoochee River Modeling Project (Georgia Department of Natural Resources, 1994a). These data were collected from 18 mainstem sampling sites and 35 tributary sampling sites located along a 113-mile reach of the Chattahoochee River downstream from Buford Dam. GaEPD water-quality samples consisted of single grab samples collected from the middle of the stream. Fecal-coliform bacteria concentrations were determined using the Multiple Tube Fermentation Technique (American Public Health Association and others, 1985) and expressed as the Most Probable Number of fecal-coliform colony forming units per 100 milliliters (MPN col/100 mL). This report describes the distribution and occurrence of fecal-coliform bacteria concentrations based on GaEPD data collected at 14 Chattahoochee River and 22 tributary stream sites in the vicinity of the CRNRA and the reach of the Chattahoochee River immediately downstream of the CRNRA directly influenced by Metropolitan Atlanta (figs. 1 and 2).

Distribution of Fecal-Coliform Bacteria

From May to October of 1994 and 1995, fecal-coliform bacteria concentrations in many streams in the study area commonly exceeded GaEPD standards and maximum concentrations recommended for the designated uses of drinking water, recreation, and fishing. During the 1994 and 1995 summer recreational seasons, 1 to 89 percent of samples collected from 14 Chattahoochee River sites and 42 to 100 percent of samples collected from 22 tributary stream sites exceeded the U.S. Environmental Protection Agency (USEPA) review criterion of 400 col/100 mL (U.S. Environmental Protection Agency, 1997).

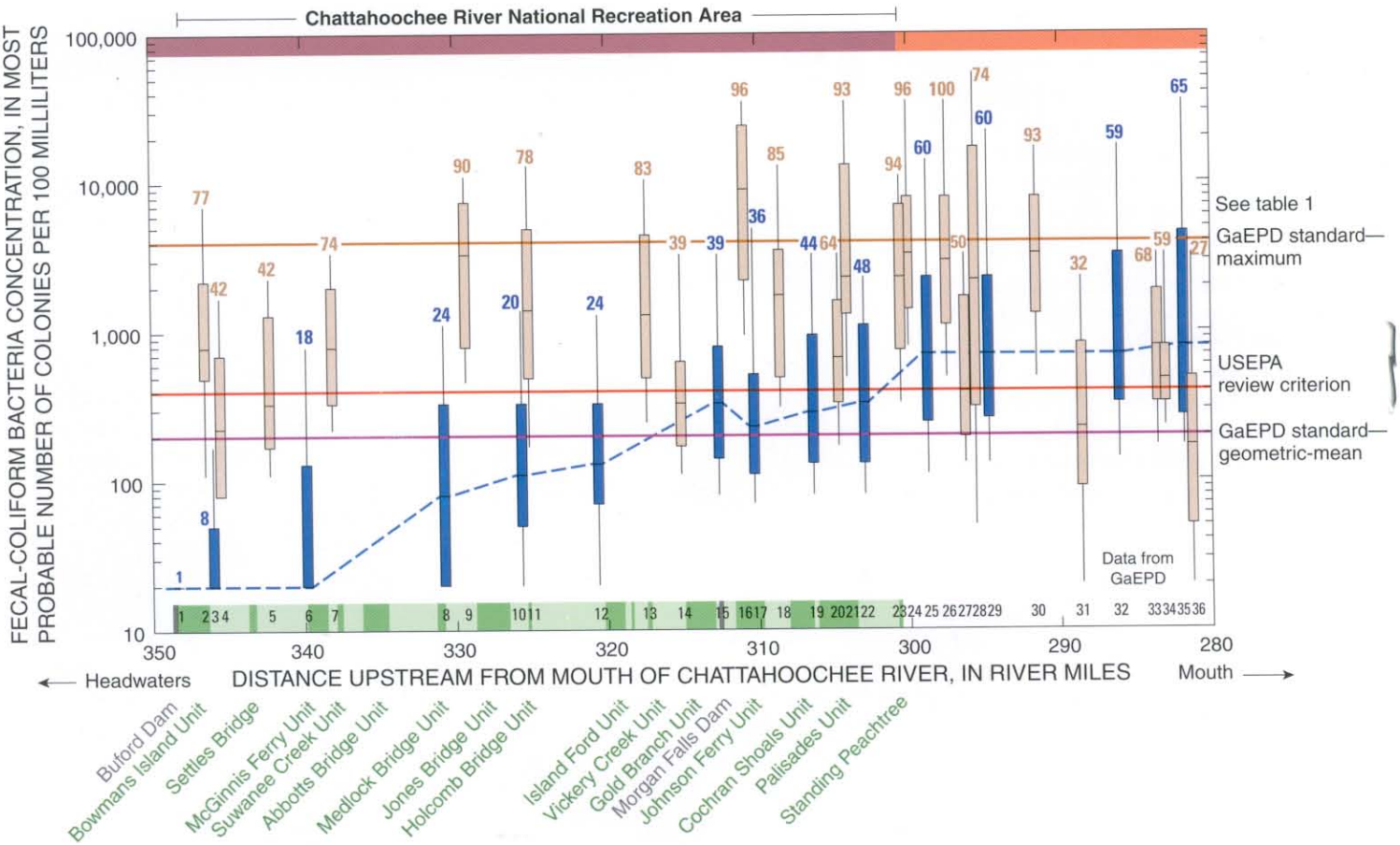


Figure 3. Fecal-coliform bacteria concentrations in the Chattahoochee River and tributary streams, Metropolitan Atlanta, May–

Table 1. Georgia Environmental Protection Division (GaEPD) fecal-coliform bacteria standards and U.S. Environmental Protection Agency (USEPA) review criterion

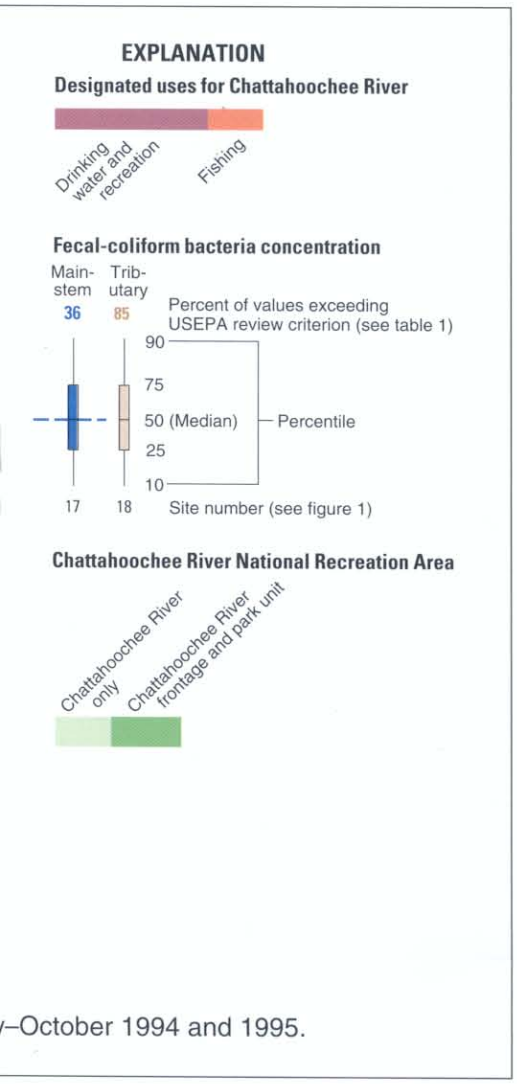
[All standards and criterion are in Most Probable Number of colonies per 100 milliliters (MPN col/100 mL); —, no standard or criterion. Modified from Georgia Department of Natural Resources, 1994b]

Designated use	Time of year that standards and criterion apply	GaEPD standards		USEPA (1997) recommended review criterion to evaluate once-per-month samples[2]
		30-day geometric mean[1]	Maximum single sample[2]	
Drinking-water supply	May–October[3]	200	—	400
	November–April	1,000	4,000	—
Recreation	Year round	200	—	400
Fishing	May–October[3]	200	—	400
	November–April	1,000	4,000	—

[1/] Based on at least four samples collected from a given site over a 30-day period at an interval not less than 24 hours. The geometric mean of a series of N terms is the N^{th} root of their product. For example, the geometric mean of 2 and 18 is 6—the square root of 36.

[2/] Waters are deemed **not supporting** designated uses (impaired) when 25 percent or more of the samples have fecal-coliform bacteria concentrations greater than the applicable review criterion or standard (400 or 4,000 MPN col/100 mL) and **partially supporting** when 11 to 25 percent of the samples exceed the review criterion or standard.

[3/] May–October is defined as the summer recreation season—the season when most water-contact activities are expected to occur. The State of Georgia does not encourage swimming in any natural surface waters because a number of factors beyond the control of any State agency contribute to elevated concentrations of fecal-coliform bacteria.



–October 1994 and 1995.

In tributary streams of the Chattahoochee River, fecal-coliform bacteria concentrations generally are higher than concentrations in the Chattahoochee River. Tributary streams having the lowest median fecal-coliform bacteria concentrations drained the least-developed areas, generally upstream and downstream from Metropolitan Atlanta, whereas tributary streams having the highest median fecal-coliform bacteria concentrations drained densely developed urban and suburban areas (fig. 3). For example, in Sope Creek, a 35-square-mile watershed in which urban and suburban areas account for 81 percent of land use in the basin (fig. 2), only a few fecal-coliform bacteria concentrations from samples collected during low-flow periods were less than the USEPA review criterion of 400 col/100 mL. During this same period, the geometric-mean fecal-coliform bacteria concentrations was never less than the level considered safe based on the GaEPD fecal-coliform bacteria standards (fig. 4).

Why are fecal-coliform bacteria monitored and how do concentrations relate to water-borne diseases? Testing for individual disease-causing agents is possible and is often done when there is a known or suspected outbreak of a water-borne disease. However, it is cost prohibitive, and in some cases technically impractical, to routinely monitor for all disease-causing bacteria, viruses, and protozoa that may be found in contaminated surface water. For routine water-quality monitoring, harmless bacteria that occur in higher numbers and originate from the same sources as the disease-causing bacteria are typically measured. The fecal-coliform bacteria group has long been the preferred indicator bacteria for Federal and State regulatory agencies and until 1986, was the primary indicator bacteria for which Federal and State regulations were based. Recent advances in the use of indicator bacteria have shown that *Escherichia coli (E. coli)* and Enterococci are more reliable for predicting the presence of disease-causing organisms and are now recommended for use in monitoring programs by the USEPA. Although the presence of indicator bacteria does not prove that pathogenic bacteria are present in the environment, the presence does show that contamination by fecal material has occurred. High concentrations of microbial indicators and concentrations that exceed standards pose an increased risk of exposure to harmful bacteria and the associated adverse effects.

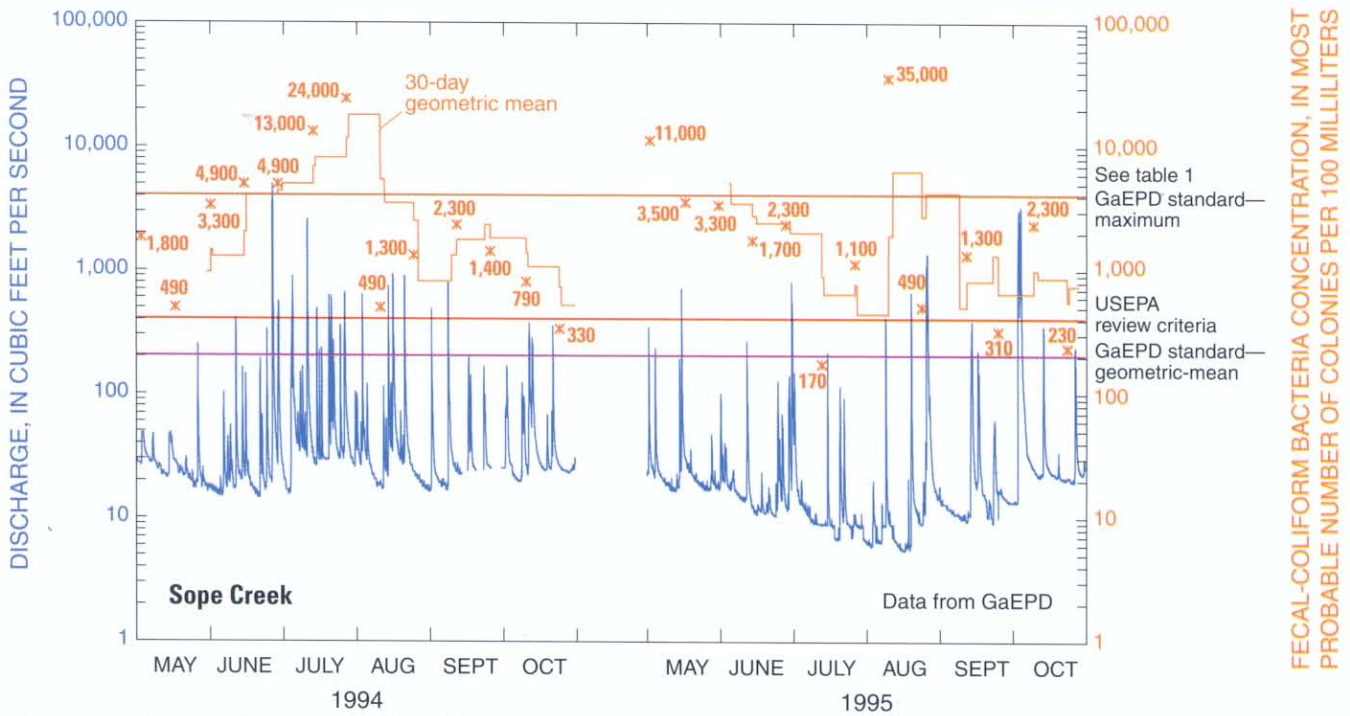


Figure 4. Stream discharge and fecal-coliform bacteria concentrations in Sope Creek, May–October 1994 and 1995. Concentrations of fecal-coliform bacteria in individual samples are denoted by an asterisk.

Concentrations of fecal-coliform bacteria depend on hydrologic conditions prior to and during sample collection. Several additional factors—including the amount of sunlight, temperature, and distance from the source of contamination—influence concentrations of fecal-coliform bacteria in a stream. During the study period, water samples collected during or immediately following a storm had fecal-coliform bacteria concentrations as much as 10 times higher than samples collected at the same site during baseflow conditions (fig. 5). Higher concentrations of fecal-coliform bacteria often occur when the contamination is the result of nonpoint sources—when overland runoff carries a high concentration of fecal-coliform bacteria from many different sources. When point sources are a significant contributor of fecal-coliform bacteria, high fecal-coliform bacteria concentrations may be present during low flows as well as during high flows. For example, in Rottenwood Creek, a Metropolitan Atlanta tributary with about 87 percent urban land use (fig. 2), approximately 15 percent of samples collected during baseflow conditions contained concentrations of fecal-coliform bacteria that exceeded the median fecal-coliform bacteria concentrations observed during storms (fig. 5).

Residential development adjacent to the Chattahoochee River.

Fecal-coliform bacteria concentrations in the Chattahoochee River generally increase downstream through Metropolitan Atlanta (fig. 3). During the study period, measured concentrations of fecal-coliform bacteria were lowest in samples collected directly downstream from Buford Dam where water from Lake Sidney Lanier is released into the river to maintain minimum flows and to produce hydroelectric power to meet peak demands. Median fecal-coliform bacteria concentrations in the water released through the dam were less than 20 MPN col/100 mL. As the Chattahoochee River flows downstream, inflow from tributaries and surface runoff increases the median fecal-coliform bacteria concentration in the river. During the study period, for about 30 miles downstream from Buford Dam to the Island Ford Unit (figs. 1 and 3), median fecal-coliform bacteria concentrations were less than the GaEPD standard of 200 MPN col/100 mL for drinking and recreational water. Within the next approximate 25-mile reach of the river, between the Island Ford and Palisades Units (figs. 1 and 3), median fecal-coliform bacteria concentrations were higher than the GaEPD standard of 200 MPN col/100 mL for drinking and recreational water, but lower than the USEPA review criterion of 400 col/100 mL. Approximately 50 miles downstream of the dam near Standing Peachtree, median fecal-coliform bacteria concentrations were consistently higher than the USEPA review criterion of 400 col/100 mL. At the four Chattahoochee River monitoring sites downstream of the CRNRA, fecal-coliform bacteria concentrations exceeded the GaEPD maximum concentration limit of 4,000 MPN col/100 mL in as many as 25 percent of the GaEPD samples collected during the summer recreational seasons in 1994 and 1995.

Median fecal-coliform bacteria concentrations in water released to the Chattahoochee River from Lake Sidney Lanier at Buford Dam were less than 20 MPN col/100 mL.

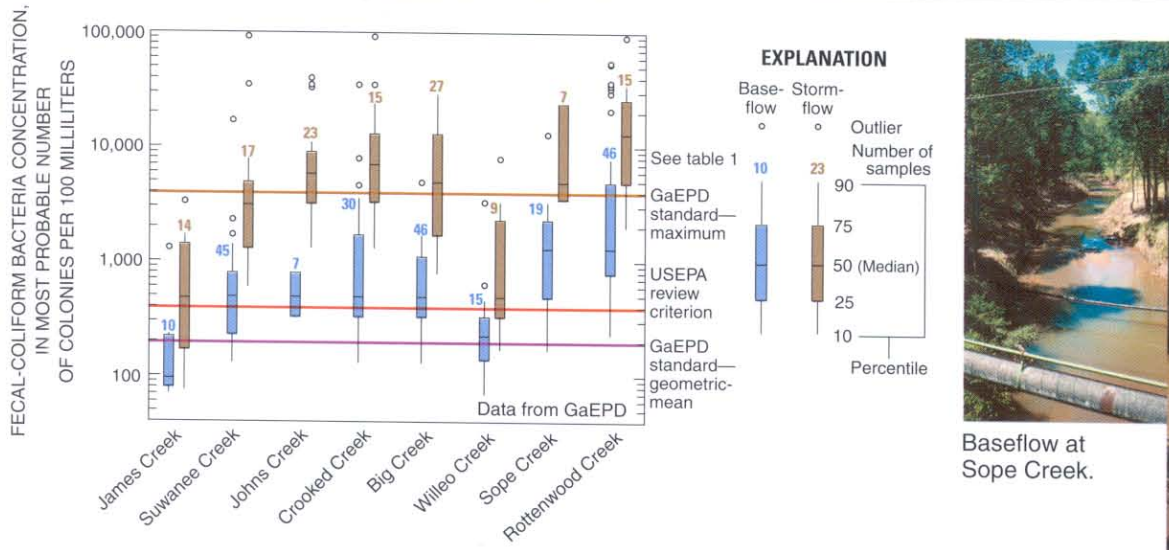


Figure 5. Comparison of fecal-coliform bacteria concentrations during baseflow and stormflow conditions in eight tributary streams, May–October 1994 and 1995.

Baseflow at Sope Creek.

Stormflow at Sope Creek.

Table 2. Human and non-human sources of fecal-coliform bacteria in urban watersheds

[Modified from Center for Watershed Protection, 1999]

HUMAN SOURCES

Sewered watersheds

- Combined sewer overflows
- Sanitary sewer overflows
- Illegal sanitary connections to storm drains
- Illegal disposal to storm drains
- Leaking sewer lines

Non-sewered watersheds

- Failing septic systems
- Small, self-contained sewage-treatment systems
- Marinas and pumpout facilities

NON-HUMAN SOURCES

Domestic animals and urban wildlife

- Dogs, cats
- Rats, raccoons
- Pigeons, gulls, ducks, geese

Livestock and rural wildlife

- Cattle, horse, poultry
- Beaver, muskrats, deer, waterfowl

Overflowing sanitary sewer.

Canada geese are year-round residents at Island Ford.

Sources of Fecal-Coliform Bacteria

Fecal-coliform bacteria in an urban watershed can originate from multiple sources depending on hydrologic conditions (table 2) and concentrations may vary in a manner similar to chemical contaminants, especially sediment-associated contaminants. Studies have shown that fecal-coliform bacteria enter streams more often from nonpoint sources during storms when fecal material from human and nonhuman sources is washed off the land and into streams. Recent research has shown that much of the fecal-coliform bacteria contamination from urban areas may come from domestic pets, such as dogs, that have high daily defecation rates and are known to harbor the disease-causing organisms *Giardia lamblia* and *Salmonella* (Center for Watershed Protection, 1999).

Fecal-coliform bacteria sources, such as combined sewer overflows and wildlife, contribute bacteria mainly through runoff during rainfall, whereas other sources, such as sanitary sewer overflows and failing septic systems, contribute bacteria during low- and high-flow conditions. Bacteria also can originate from point sources such as leaking sewers or malfunctioning waste water treatment equipment, or in leachate from failing septic systems. Combined sewers carry a combination of stormwater runoff and untreated sewage and often overflow during storms, resulting in the discharge of untreated waste being discharged into streams. Although no combined sewer overflows exist within or upstream from the CRNRA, sanitary sewer lines are commonly routed along tributary stream corridors. When sanitary sewer lines overflow as a result of equipment failures, these overflows are sources of fecal-coliform bacteria contamination in the CRNRA. Other research has shown that bacteria may collect and settle within dense urban drainage networks and may persist for weeks or months before being transported to local streams (Center for Watershed Protection, 1999).

Current Research

Although concentrations of fecal-coliform bacteria that exceed GaEPD standards and the USEPA review criterion are common in Metropolitan Atlanta streams, the situation is not unique to the metropolitan area. According to a nationwide study, bacterial contamination was ranked as the third most common cause for water-body impairment in the United States during 1996 (Armitage and others, 1999). Earlier in the 20th century, waterborne diseases (table 3) were a greater threat to human health in the United States than now. However, currently the threat of waterborne disease exists for humans living in densely populated areas (Burke, 1993). These risks have the potential to be even greater in areas where undertreated or untreated wastewater effluent and runoff from highly urbanized areas contribute to drinking-water source supply intakes, or where recreational contact with contaminated water may occur.

Additional information on sources and transportation pathways is needed to support improved regulations, to reduce current levels of fecal-coliform bacteria, and to manage water resources in urban areas. Factors determining the concentration of fecal-coliform bacteria, including sources, must first be known and understood before any short-term management plans are implemented. Part of current USGS and NPS research is to utilize a genetic fingerprinting technique using *E. coli* bacteria present in fecal samples from humans, domestic animals, livestock, poultry, and wildlife to try to track microbial sources within the Chattahoochee River basin. If successful, this research may benefit the NPS and water-resource managers in the Metropolitan Atlanta area by determining the relative importance of various sources of microbial contamination in tributaries and reaches of the Chattahoochee River.

Urban streams in Metropolitan Atlanta often do not support recreational uses because of high levels of indicator bacteria.

Table 3. Acute and chronic health effects associated with common waterborne microorganisms

[Modified from American Society for Microbiology, 1999]

AGENT	HEALTH EFFECTS	
	Acute	Chronic
Bacteria		
E. coli (O157:H7)	Diarrhea	Adults: death from thrombocytopenia Children: death from kidney failure
Campylobacter	Diarrhea	Death from Guillian-Barre syndrome
Salmonella	Diarrhea	Reactive arthritis
Shigella	Diarrhea	Reactive arthritis
Protozoa		
Giardia lamblia	Diarrhea	Failure to thrive Severe hypothyroidism Lactose intolerance Chronic joint pain
Cryptosporidium	Diarrhea	Death in immuno-compromised humans
Viruses		
Hepatitis viruses	Liver infections	Liver failure
Norwalk virus	Diarrhea	

What are bacteria and which ones cause waterborne diseases? Bacteria are a numerous and diverse assemblage of single-celled organisms and are a natural component of lakes, rivers, and streams. Over 60 genera of bacteria are present in these aquatic systems, with absolute numbers ranging from 40,000 to over 12 million cells in the amount of water that would cover the bottom of an average-sized coffee cup (Lynch and Hobbie, 1988). Most of these bacteria are harmless to humans; however, certain bacteria, some of which normally inhabit the intestinal tract of warm-blooded animals, have the potential to cause sickness and disease in humans. Elevated numbers of these harmless bacteria are associated with increased numbers of harmful bacteria as well as other disease-causing organisms such as viruses and protozoans. Consumption of, or recreational contact with, water contaminated with feces of warm-blooded animals can cause a variety of illnesses. Minor gastrointestinal discomfort is probably the most common symptom; however, pathogens that may cause only minor sickness in some people may cause serious conditions or death in others, especially in the very young, old, or immuno-compromised.

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